PB-240 504

WHITE BEAR LAKE, RAMSEY AND WASHINGTON COUNTIES, MINNESOTA

Pacific Northwest Environmental Research Laboratory

Prepared for:

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National Environmental Research Center, Las Vegas, Nevada
Minnesota Pollution Control Agency
Minnesota National Guard

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16. ABSTRACT
Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivded according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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REPORT
ON
WHITE BEAR LAKE
RAMSEY AND WASHINGTON COUNTIES
MINNESOTA

EPA REGION V

WORKING PAPER No. 144

WITH THE COOPERATION OF THE

MINNESOTA POLLUTION CONTROL AGENCY

AND THE

MINNESOTA NATIONAL GUARD

DECEMBER, 1974

II

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS*

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

* The lake discussed in this report was included in the National Eutrophication Survey as a lake of special interest to the Minnesota Pollution Control Agency. For this reason, tributaries and nutrient sources were not sampled and this report relates only to data obtained from lake sampling.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Minnesota Pollution Control Agency for professional involvement and to the Minnesota National Guard for conducting the tributary sampling phase of the Survey.

Grant J. Merritt, Director of the Minnesota Pollution Control Agency, John F. McGuire, Chief, and Joel G. Schilling, Biologist, of the Section of Surface and Groundwater, Division of Water Quality, provided invaluable lake documentation and counsel during the course of the Survey; and the staff of the Section of Municipal Works, Division of Water Quality, were most helpful in identifying point sources and soliciting municipal participation in the Survey.

Major General Chester J. Moeglein, the Adjutant General of Minnesota, and Project Officer Major Adrian Beltrand, who directed the volunteer efforts of the Minnesota National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

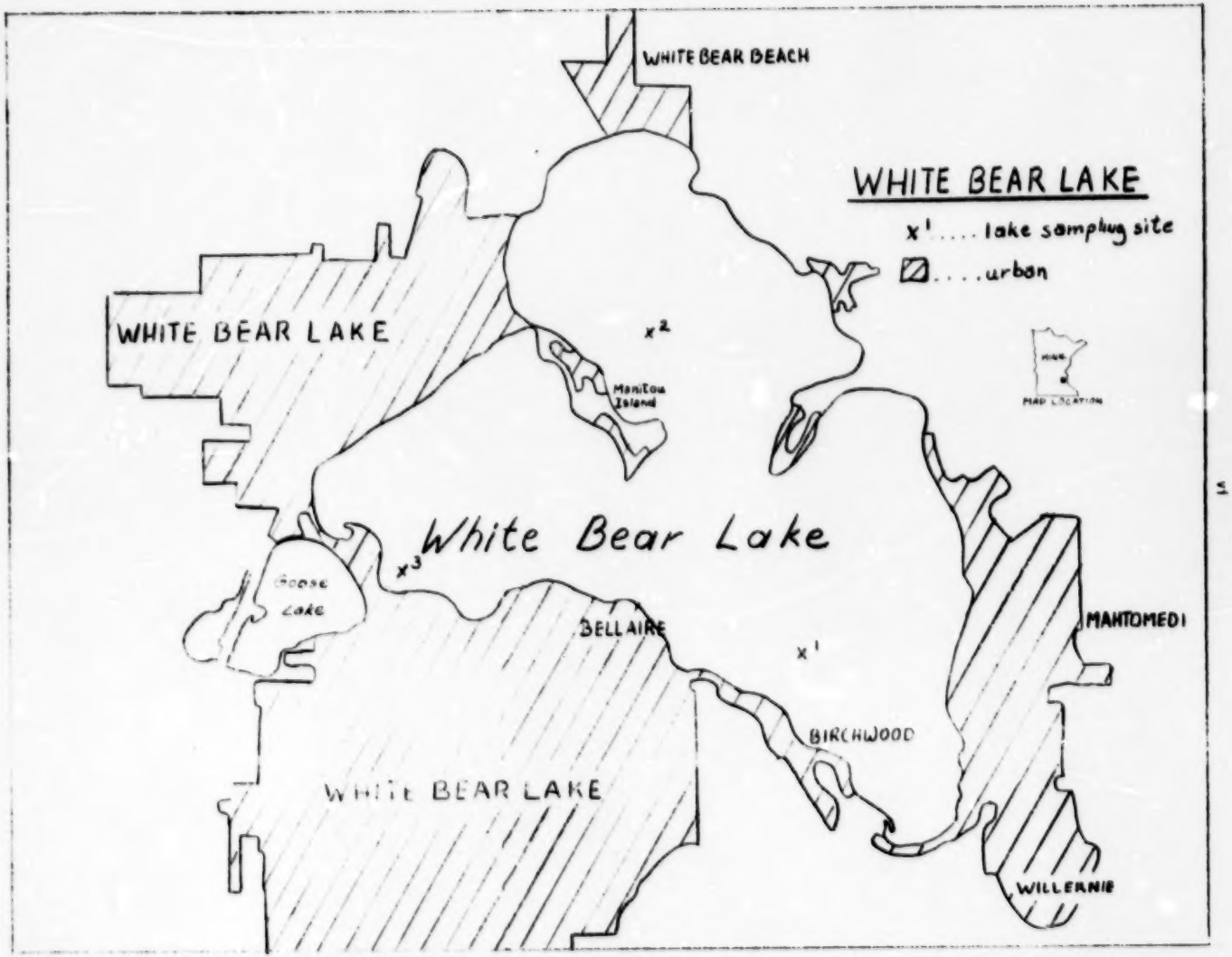
NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF MINNESOTA

LAKE NAME	COUNTY
Albert Lea	Freeborn
Andrusia	Beltrami
Badger	Polk
Bartlett	Koochiching
Bear	Freeborn
Bemidji	Beltrami
Big	Stearns
Big Stone	Big Stone, MN; Roberts, Grant, SD
Birch	Cass
Blackduck	Beltrami
Blackhoof	Crow Wing
Budd	Martin
Buffalo	Wright
Calhoun	Hennepin
Carlos	Douglas
Carrigan	Wright
Cass	Beltrami, Cass
Clearwater	Wright, Stearns
Cokato	Wright
Cranberry	Crow Wing
Darling	Douglas
Elbow	St. Louis
Embarass	St. Louis
Fall	Lake
Forest	Washington
Green	Kandiyohi
Gull	Cass
Heron	Jackson
Leech	Cass
Le Homme Dieu	Douglas
Lily	Blue Earth
Little	Grant
Lost	St. Louis

LAKE NAME	COUNTY
Madison	Blue Earth
Malmedal	Pope
Mashkenode	St. Louis
McQuade	St. Louis
Minnetonka	Hennepin
Minnewaska	Pope
Mud	Itasca
Nest	Kandiyohi
Pelican	St. Louis
Pepin	Goodhue, Wabasha, MN; Pierce, Pepin, WI
Rabbit	Crow Wing
Sakatah	Le Sueur
Shagawa	St. Louis
Silver	McLeod
Six Mile	St. Louis
Spring	Washington, Dakota
St. Croix	Washington, MN; St. Croix, Pierce, WI
St. Louis Bay	St. Louis, MN; Douglas, WI
Superior Bay	St. Louis, MN; Douglas, WI
Swan	Itasca
Trace	Todd
Trout	Itasca
Wagonga	Kandiyohi
Wallmark	Chisago
White Bear	Washington
Winona	Douglas
Wolf	Beltrami, Hubbard
Woodcock	Kandiyohi
Zumbro	Olmstead, Wabasha


WHITE BEAR BEACH
WHITE BEAR LAKE
x¹.... lake samplug site
....urban
WHITE BEAR LAKE
x²
Manitou Island
MAP LOCATION
White Bear Lake
x³
Goose Lake
BELLAIRE
x¹
MAHTOMEDI
BIRCHWOOD
WHITE BEAR LAKE
WILLERNIE

WHITE BEAR LAKE

STORET NO. 2780

I. INTRODUCTION

White Bear Lake was included in the National Eutrophication Survey as a water body of interest to the Minnesota Pollution Control Agency. Tributaries and nutrient sources were not sampled, and this report relates only to the data obtained from lake sampling.

II. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that White Bear Lake is mesotrophic. Of the 60 Minnesota lakes sampled in the fall when essentially all were well-mixed, none had less mean total and dissolved phosphorus, and only eight had less mean inorganic nitrogen. Of the 80 Minnesota lakes sampled, only eight had less mean chlorophyll a, and only two had greater Secchi disc transparency.

Dissolved oxygen was depleted in the deepest samples at stations 1 and 2 in August.

B. Rate-Limiting Nutrient:

The algal assay results indicate that the lake was phosphorus limited at the time the sample was collected. The lake data indicate phosphorus limitation at the other sampling times as well.

III. LAKE MORPHOMETRY*

A. Surface Area: 2,659 acres.

B. Mean Depth: 22.6 feet.

C. Maximum Depth: 80 feet.

D. Volume: 60,093 acre feet.

IV. PRECIPITATION

A. Year of Sampling: 31.4 inches.

B. Mean Annual: 30.9 inches.

* DNR lake survey map (1954); mean depth by random-dot method.

V. LAKE WATER QUALITY SUMMARY

White Bear Lake was sampled three times during the open-water season of 1972 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from three stations on the lake and from a number of depths at each station (see map, page vi). During each visit, a single depth-integrated (15 feet or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the last visit, a single five-gallon depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 78 feet at station 1, 34 feet at station 2, and 15 feet at station 3.

The results obtained are presented in full in the Appendix and the data for the fall sampling period, when the lake essentially was well-mixed, are summarized below. Note, however, the Secchi disc summary is based on all values.

For differences in the various parameters at the other sampling times, refer to the Appendix.

A. Physical and chemical characteristics:

Parameter	Minimum	Mean	Median	Maximum
		FALL VALUES (11/05/72)		
Temperature (Cent.)	5.5	6.1	6.2	6.3
Dissolved oxygen (mg/l)	10.9	11.2	11.2	11.6
Conductivity (μmhos)	250	257	255	270
pH (units)	8.2	8.2	8.2	8.2
Alkalinity (mg/l)	109	112	112	114
Total P (mg/l)	0.010	0.013	0.012	0.017
Dissolved P (mg/l)	0.004	0.007	0.007	0.009
NO_2 + NO_3 (mg/l)	0.030	0.035	0.030	0.050
Ammonia (mg/l)	0.050	0.059	0.060	0.070
		ALL VALUES		
Secchi disc (inches)	104	136	122	175

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Number per ml
06/29/72	1. Microcystis	897
	2. Dinobryon	784
	3. Fragilaria	271
	4. Chroococcus	136
	5. Flagellates	83
	Other genera	369
	Total	2,540
08/27/72	1. Microcystis	1,160
	2. Dinobryon	542
	3. Chroococcus	279
	4. Fragilaria	166
	5. Anabaena	136
	Other genera	392
	Total	2,675
11/05/72	1. Flagellates	1,859
	2. Dinobryon	1,231
	3. Anabaena	402
	4. Fragilaria	327
	5. Nitzchia	251
	Other genera	1,332
	Total	5,402

2. Chlorophyll a -
(Because of instrumentation problems during the 1972 sampling, the following values may be in error by plus or minus 20 percent.)

Sampling Date	Station Number	Chlorophyll a (µg/l)
06/29/72	01	4.2
	02	5.9
	03	6.9
08/27/72	01	3.3
	02	4.8
	03	3.4
11/05/72	01	8.3
	02	7.3
	03	2.5

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)	N/P Ratio
Control	0.003	0.081	0.3	27/1
0.006 P	0.009	0.081	1.4	9/1
0.012 P	0.015	0.081	1.6	5/1
0.024 P	0.027	0.081	1.6	-
0.060 P	0.063	0.081	1.6	-
0.060 P + 10.0 N	0.063	10.081	34.8	160/1
10.0 N	0.003	10.081	0.3	

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the primary productivity of White Bear Lake was quite low at the time the sample was collected.

The signficant increase in yield with the first phosphorus spike but lack of significant changes in yield with subsequent

P-spikes indicates that White Bear Lake was narrowly phosphorus limited. Note that the addition of only 6 µg/l of orthophosphorus shifted the sample from phosphorus limitation (N/P = 27/1) to nitrogen limitation (N/P = 9/1).

The lake data indicate phosphorus limitation at the other sampling times as well (N/P ratios were 14/1 or greater).

VI. LITERATURE REVIEWED

Allen, Gerald S., 1963. Report on investigation of pollution of White Bear Lake. MN Dept. of Health, Minneapolis.

VII. Appendix

STORET RETRIEVAL DATE 74/10/30

27H001
45 03 55.0 092 58 28.0
WHITE BEAR LAKE
27 MINNESOTA

11EPALES 2111202
3 0050 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/04/29	10 20	0000	21.5	7.8	170	250	8.30	113	0.050	0.040	0.012	0.008
	10 20	0015	21.5			250	8.30	114	0.130	0.060	0.014	0.009
	10 20	0025	18.9			260	8.00	118	0.170	0.060	0.017	0.009
	10 20	0035	10.0	3.J		265	7.20	120	0.150	0.070	0.035	0.008
72/04/27	09 30	0000			122	240	8.40	105	0.050	0.040	0.017	0.012
	09 30	0004	19.9	7.2		270	8.40	103	0.060	0.060	0.019	0.012
	09 30	0010	20.0	7.5		240	8.35	111	0.040	0.070	0.019	0.013
	09 30	0015	19.9	7.5		240	8.40	111	0.010K	0.020	0.018	0.012
	09 30	0020						110	0.050	0.070	0.017	0.012
	09 30	0025						108	0.040	0.060	0.016	0.014
	09 30	0035						118	0.040	0.140	0.034	0.020
	09 30	0045	10.4	0.0		270	7.05	124	0.100	0.440	0.071	0.023
72/11/05	15 00	0000			119	260	8.20	110	0.040	0.050	0.010	0.004
	15 00	0004	6.3	11.2		255	8.20	109	0.040	0.060	0.011	0.007
	15 00	0015	6.3	10.9		255	8.20	109	0.040	0.060	0.017	0.007
	15 00	0025	6.3	11.2		255	8.20	109	0.040	0.060	0.013	0.007
	15 00	0035	6.2	11.1		255	8.20	112	0.030	0.050	0.013	0.006
	15 00	0045	6.2	11.0		255	8.20	114	0.040	0.060	0.011	0.005
	15 00	0055	6.2	10.9		255	8.20	113	0.030	0.050	0.014	0.007
	15 00	0065	6.2	10.9		255	8.20	112	0.050	0.070	0.013	0.009
	15 00	0078	6.2	11.1		250	8.20	114	0.030	0.060	0.011	0.006

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/04/29	10 20	0000	4.2J
72/08/27	09 30	0000	3.3J
72/11/05	15 30	0000	8.3J

J VALUE KNOWN TO BE IN ERROR

K VALUE KNOWN TO BE LESS THAN INDICATED

STORET RETRIEVAL DATE 74/10/30

278003
45 04 15.0 093 00 24.0
WHITE BEAR LAKE
27 MINNESOTA

11EPALES 2111202
3 0020 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/29	11 30	0000	22.0		166	230	8.40	109	0.050	0.040	0.012	0.006
	11 30	0015	20.0	9.0		245	8.20	114	0.050	0.050	0.020	0.010
72/08/27	10 30	0000			108	262	8.20	105	0.050	0.080	0.020	0.016
	10 30	0004	19.0	6.7		239	8.15	103	0.100	0.130	0.019	0.020
	10 30	0008	19.0	6.8		240	8.20	103	0.050	0.050	0.020	0.012
72/11/05	14 35	0000			119	260	8.20	114	0.030	0.050	0.012	0.006
	14 35	0004	5.5	11.6		255	8.20	113	0.030	0.060	0.012	0.007
	14 35	0011	5.5	11.5		255	8.20	113	0.030	0.060	0.012	0.007

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/29	11 30	0000	6.9J
72/08/27	10 30	0000	3.4J
72/11/05	14 35	0000	2.5J

J* VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 74/10/30

278002
45 05 22.0 092 59 15.0
WHITE BEAR LAKE
27 MINNESOTA

11EPALES
3

2111202
0040 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/29	11 10	0000	21.5	7.4	175	245	8.30	112	0.060	0.040	0.012	0.008
	11 10	0015	20.0			250	8.20	114	0.060	0.050	0.014	0.008
	11 10	0030	12.5	4.0		260	7.30	117	0.050	0.040	0.037	0.008
72/08/27	13 30	0000	20.0		104	240	8.40	106	0.040	0.060	0.010	0.005
	13 30	0004	20.0	8.0		240	8.40	107	0.050	0.070	0.013	0.005
	13 30	0015	19.9	7.9		240	8.40	106	0.040	0.070	0.012	0.005
	13 30	0025	19.2	7.7		240	8.40	106	0.040	0.070	0.010	0.005
	13 30	0034	13.8	0.0		275	7.10	124	0.100	0.500	0.098	0.020
72/11/05	13 15	0000			140	270	8.20	112	0.040	0.070	0.011	0.007
	13 15	0004	6.1	11.2		260	8.20	111	0.030	0.050	0.013	0.007
	13 15	0015	6.1	11.2		250	8.20	110	0.030	0.060	0.014	0.007
	13 15	0025	6.1	11.2		270	8.20	111	0.030	0.070	0.014	0.008

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/29	11 10	0000	5.9J
72/08/27	13 30	0000	4.8J
72/11/05	13 15	0000	7.3J

J= VALUE KNOWN TO BE IN ERROR

12